PROJECT FINAL REPORT
Upper Caroline Brook Restoration Project
Project No. 15-03/319
2015-2017

GRANTEE:
David J. Hickey, Jr., P.E.
Town Engineer

Malcolm Harper
Mass DEP Project Manager

Prepared for:

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF RESOURCE PROTECTION
and
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 1

MASSACHUSETTES EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
Matthew A. Beaton, Secretary

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Martin Suuberg, Commissioner

BUREAU OF WATER RESOURCES
Douglas Fine, Assistant Commissioner

DIVISION OF MUNICIPAL SERVICES
Steven J. McCurdy, Director

Upper Caroline Brook Restoration Project
Project 15-03/319

CONTENTS

This project has been financed with federal funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (MassDEP) under a (Sec. 319, 604b, etc.) competitive grant. The contents do not necessarily reflect the views and policies of EPA or the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

A. Project Snapshot

Upper Caroline Brook Restoration Project
Project No. 15-03/319
Project Start Date: March 30, 2015
Date Closed: April 7, 2017

Charles River Watershed
HUC-12: 010900010701
Sub-basin: Fuller Brook, Segment MA 72-18
Status: Impaired for pathogens and nutrients

Upper Caroline Brook, from Seaward Road to State Street, is part of the Charles River Watershed, located in the Town of Wellesley south of Route 135 and is a tributary to the Fuller Brook which is listed as a Category 5 for impaired for physical substrate habitat alterations, E. coli, nutrients/eutrophication biological indicators, and sedimentation in the MassDEP 2012 Integrated List of Waters.

The project addresses water quality impairments in Caroline Brook and Fuller Brook with the installation of BMPs that should reduce pollutant loading from stormwater runoff and streambank erosion in the upper Caroline Brook, and BMPs improving habitat within the stream corridor such as rock vanes. Reducing the loading to the headwaters of the upper Caroline Brook is anticipated to be a major step in improving the condition of the water quality in upper Caroline Brook and Fuller Brook.

The project has included the installation of bioretention retrofits, disconnecting a discharge from an unpaved road, stream stabilization practices, i.e., cross vanes, vegetative stabilization, etc., and relocating the streambed below the Forest Street culvert to protect an undermined sewer main. The following table shows calculated pollutant loads and estimated removal due to the project. The total pollutant load removed from bioretention 1 & 2 is as follows.

Summary Total Pollutant Load Removal

	TSS (#/yr)	TP (#/yr)	TN (#/yr)	Bacteria (#col/100 ml)
Bioretention 1	545.4	2	11	180
Deep Sump CB 3	202	0	0	0
Bioretention 2	2,415	8	47	787
Deep Sump CB 1	438	0	0	0
Deep Sump CB 2	456			
TOTALS	**4,056.4**	**10**	**58**	**967**

BMP Pollutant Load Calculations

The Simple Method - Pollutant Loading Calculations

Assumptions

	C values (mg/L)
	residential runoff *
TSS	100
Phosphorus - total	0.4
Nitrogen - total	3.31
Bacteria (#col/100ml)	7,000

* From The Watershed Treatment Model, 2001

Simple Method - Chemical constituents

L=0.226*R*C*A
L=Annual load (lbs)
R=Annual runoff (inches)
C=pollutant concentration (mg/l)
A=Drainage Area (acres)
0.226=Unit conversion factor

R=P*Pj*Rv
R=Annual runoff (inches)
P=Annual rainfall (inches)
Pj=Fraction of annual rainfall events that produced runoff, typically (0.9)
Rv=runoff coefficient=0.05+0.9Ia
Ia=Impervious fraction

Simple Method - Bacteria

L=1.03*(10^-3)*R*C'*A
L=Annual load (Billion Colonies/yr)
R=Annual runoff (inches)
C'=flow-weight mean concentration (#col/100ml)
A=Drainage Area (acres)
1.03=Unit conversion factor

R=P*Pj*Rv
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Pj=Fraction of annual rainfall events that produce runoff, typically (0.9)
Rv=runoff coefficient=0.05+0.9Ia
Ia=Impervious fraction

Suggested Removal Rates for BMP's (Massachusetts Stormwater Standards, 2008

	TSS	TP	TN	Bacteria (CWP, 2007)
Biorentention Systems	90%	60%	40%	70%
Deep Sump Catch Basins	25%	0	0	0

Bioretention 1 - Caroline Street

Total Area (acres)	3.8	Ia=	22%	
Impervious Area (acres)	0.84	Rv=	25%	
		P=	42	NOAA-Boston
		R=	9.41	

	TSS	TP	TN	Bacteria
C (residential)=	100	0.4	3.31	7000
Annual Load, L (lbs/yr)=	808	3.2	26.7	257.8

Deep Sump Catch Basin 3

	TSS	TP	TN	Bacteria
Load Removed (lbs/yr)*	202	0	0	0
Total Load Remaining (lbs/yr)	606	0	0	0
Difference	25%	0	0	0

Removal from Bioretention 1 (treating 100% of WQv)

	TSS	TP	TN	Bacteria
Load Removed (lbs/yr)*	545.4	2	11	180
Total Load Remaining (lbs/yr)	60.5	1.3	16	77.3
Difference	90%	60%	40%	70%

* Based on removal ability of practice AND percent of WQv treated

Bioretention Area 2 - Seaward Road

Total Area (acres)	7.60	Ia=	24%	
Impervious Area (acres)	1.8	Rv=	27%	
		P=	42	NOAA-Boston
		R=	10.2	

Bioretention Area 2 – Abbott Road

Total Area (acres)	4.75	Ia=	44%	
Impervious Area (acres)	2.1	Rv=	45%	
		P=	42	NOAA-Boston
		R=	17	

Deep Sump Catch Basin 1

	TSS	**TP**	**TN**	**Bacteria**
C (residential)=	100	0.4	3.31	7,000
Annual Load, L (lbs/yr)=	1,752	14.1	116.7	1,124.9

Deep Sump Catch Basin 2

	TSS	**TP**	**TN**	**Bacteria**
C (residential)=	100	0.4	3.31	7,000
Annual Load, L (lbs/yr)=	1,825	14.1	116.7	1,124.9

Deep Sump Catch Basin 1

	TSS	**TP**	**TN**	**Bacteria**
Load Removed (lbs/yr)*	438	0	0	0
Total Load Remaining (lbs/yr)	1,314	0	0	0
Difference	25%	0	0	0

Deep Sump Catch Basin 2

	TSS	**TP**	**TN**	**Bacteria**

Load Removed (lbs/yr)*	456	0	0	0
Total Load Remaining (lbs/yr)	1,369	0	0	0
Difference	25%	0	0	0

Removal from Bioretention Area 2(treating 100% of WQv)

	TSS	**TP**	**TN**	**Bacteria**
Load Removed (lbs/yr)*	2,415	8	47	787
Total Load Remaining (lbs/yr)	268	5.6	70	337.5
Difference	90%	60%	40%	70%

* Based on removal ability of practice AND percent of WQv

<u>Streambank Stabilization – Estimated Pollutant Load Reductions</u>

The effectiveness of stream restoration for pollutant removal has not been fully ascertained. However, EPA's Chesapeake Bay Program issued a guidance document in 2005 indicating how it would credit jurisdictions for reducing pollutant loads to the bay and its tidal rivers by means of stream restoration. In the guidance, the Chesapeake Bay Program included removal-efficiency rates based on research involving one stream restoration project along Spring Branch in Baltimore County, MD (USEPA 2005). The research included monitoring data from one year before and three years after construction of the Spring Branch project. For every linear foot of stream restored, the EPA guidance stipulates removals of 2.55 pounds per year of TSS, 0.02 pound per year of TN, and 0.0035 pound per year of TP.
http://foresternetwork.com/daily/water/stormwater/comparing-lid-and-stream-restoration/

Stabilization Location	Length of stream stabilization (LF)	TSS Removed (lbs/year)	TP Removed (lbs/year)	TN Removed (lbs/year)
Streambank Stabilization Forest St. to Caroline St. (Add Alt. 1 on plans)	615	1568.25	2.2	12.3
Stream Relocation and Restoration Area	285	726.8	1.0	5.7
TOTAL	**900**	**2,295**	**3.15**	**18**

B. Descriptive Project Summary

PROJECT TITLE: Upper Caroline Brook Restoration Project
NPS CATEGORY: Resource Restoration
INVESTIGATOR: Town of Wellesley
LOCATION: Charles River Watershed
TARGETED POLLUTANTS: Total Suspended Solids, Total Phosphorous, Total Nitrogen, Bacteria

Project Overview: The project addresses water quality impairments in the Fuller Brook, listed as a Category 5 for impaired for physical substrate habitat alterations, E. coli, nutrients/ eutrophication biological indicators, and sedimentation, by designing, installing, and maintaining BMPs to reduce pollutant loading from stormwater runoff and streambank erosion in the upper Caroline Brook, and BMPs improving habitat within the stream corridor. Reducing the loading to the headwaters of the upper Caroline Brook is a major step in improving the condition of the water quality in upper Caroline Brook and Fuller Brook.

The project goals were to reduce pollutant loads from stormwater runoff entering the brook with no treatment and from eroding streambanks. Installed BMPS included bioretention basins, installation of deep sump catch basins, routing road drainage through newly constructed bioretention basins, disconnecting a discharge from an unpaved road, hard and soft steam stabilization practices (cross vanes, vegetative stabilization), and relocating the streambed to protect an undermined sewer main.

Project Objectives:

1. Design and Construct Stormwater Management BMPs
2. Prepare and Fund BMP Operation and Maintenance Plan
3. Provide Public Education and Outreach relative to Stormwater Management

Methods: The Town of Wellesley had undertaken a five-year process of planning and design for Fuller Brook Park that included recommendations for the current project. The Town contracted with a design and engineering team including BETA Group, Inc. and Horsley Witten Group to prepare designs and bid documents for the Fuller Brook Park Preservation Project. Bids were received on February 12, 2014 and Notice to Proceed for construction was issued to R. Bates & Sons, Inc. on May 15, 2014.

Work on the Upper Caroline Brook Restoration portion of the larger Fuller Brook Park project began in Fall 2014 and was essentially completed in Fall 2015. Public education and outreach were included throughout the project in the form of tours of the work with local groups and maintaining a project website that provided information about the work and photographs of progress. A project citizen advisory committee, Fuller Brook Park Committee, was also established to represent citizen concerns and provide a link to park neighbors.

Results: Two bioretention basins, with a total surface area of over 6,000 sf were constructed to filter a portion of the stormwater from three streets representing a drainage area of over 16 acres. Stream and bank restoration on Upper Caroline Brook included 900 linear feet of stream course and 1800 linear feet of stream bank. Stream relocation included 290 linear feet of stream and creation of approximately 8,400 sf of wetland and wet meadow adjacent to its banks.

The Public Outreach and Education Program was an important aspect of the project and contributes greatly to the project success. The town developed and continues to maintain a project website that is updated approximately two time per month. The site provides photos and written descriptions of completed work and in process work. It provides contact information and invites comments. The town established a citizen advisory committee for the project to help guide decision making and act as a conduit for information between the project and the public.

The grant helped fund the design, fabrication, and installation of two interpretive signs in the park providing visitors with explanations of stormwater management and the bioretention basins and with the infrastructure protection and ecological design of the stream relocation aspect of the project.

PROJECT COST:	$561,792
FUNDING:	$337,048 by the US EPA
	$247,149.65 by the Town of Wellesley
DURATION:	March 30, 2015 – June 30, 2016

C. Project Finances

Overview: Since the Fuller Brook project construction contract had gone to bid prior to the establishment of the budget contained in the grant application, the project budget was based on real bid amounts. This resulted in a close match between the grant budget and actual construction costs.

Project Budget
Upper Caroline Brook Restoration Project
15-02/319

Expense Items	s.319 Amount	Non-Federal Match	Total Amount
Salaries, Fringe and Overhead (Town of Wellesley)		$42,943	$42,943
Town Engineer ($59-69/hr)			
Project Manager ($45-55/hr)			
Landscape Arborist ($45-50/hr)			
Parks Superintendent ($44-50/hr)			
Subtotal		**$42,943**	**$42,943**
Subcontractual Services			
BMP Design		$29,200	$29,200
BMP Construction	$326,169	$148,757	$474,926
Subtotal	**$326,169**	**$177,957**	**$504,126**
Materials and Supplies:			
Printing Postage, and Signage	**$ 10,879**	$3,844	$14,723
Subtotal		**$3,844**	**$14,723**
10% Retainage	**$ 33,704.80**		
Totals:	**$337,048**	**$224,744**	**$561,792**
Percent	**60%**	**40%**	**100%**

The Disadvantaged Business Enterprise, (DBE) Program "Fair Share" goals for the project are: $19,101 for D/MBE (3.4%) and for $21,348 D/WBE (3.8%). Firms utilized in Federally Assisted Projects must be certified as either an MBE or WBE *and* a DBE.

Actual Project Costs

Task		Total Cost
Subcontracted Services		
1. Final Design/Permitting (includes interpretive sign)		$ 27,728.53
2. Construction of BMP's (includes interpretive sign)		$ 486,646.90
3. Consultant Support Construction Oversight		$ 19,866.00
	Subtotal:	**$ 534,241.43**
Services by Town Employees		
1. Construction Oversight		$ 35,296.00
2. Operations and maintenance Plan		$ 3,786.00
3. Outreach and Education		$ 2,019.20
4. Project Evaluation		$ 2,019.20
5. Grant Administration		$ 24,606.36
	Subtotal:	**$ 67,726.76**
	TOTAL	**$ 601,968.19**

D. Description of BMPs

1. Bioretention Area 1, was constructed in October- November 2014 and placed in service November 14, 2014. It is approximately 1,460 square feet in area located at station 104+50 on Caroline Street at Caroline Brook. Bioretention Area 1 consists of an underdrain system, pea gravel, bioretention soils and a hardwood mulch. Stormwater runoff that enters the bioretention area first passes through a sediment forebay with a stone checkdam utilizing a stabilizer with landscape river stone. The sediment forebay acts as a pretreatment for stormwater runoff entering the bioretention area to remove trash, debris and sediment. The subsurface underdrain pipe system that collects stormwater runoff from the bioretention area is conveyed to a culvert downstream. The following table shows calculated pollutant loads and estimated removal due to bioretention area 1.

	TSS (#/yr)	TP (#/yr)	TN (#/yr)	Bacteria (#col/100 ml)
Bioretention Area 1	545.5	2	11	180

2. Bioretention Area 2, which was installed in September- October 2014 and placed in service November 14, 2016. It is approximately 4,590 square feet in area located at station 107+50 to station 110 between Seaward Road and Abbott Road. Bioretention Area 2 consists of an underdrain system, pea gravel, bioretention soils and a hardwood mulch. Stormwater runoff that enters the bioretention area, first passes through a sediment forebay at two separate locations, Seaward Road and Abbott Road, with a stone checkdam utilizing a stabilizer with landscape river stone. The sediment forebay acts as a pretreatment for stormwater runoff entering the bioretention area to remove trash, debris and sediment. The subsurface underdrain pipe system that collects stormwater runoff from the bioretention area is conveyed to a culvert downstream. The following table shows calculated pollutant loads and estimated removal due to bioretention area 2.

	TSS (#/yr)	TP (#/yr)	TN (#/yr)	Bacteria (#col/100 ml)
Bioretention Area 2	2,415	8	47	787

3. Other structural BMP’s that were installed as part of the Caroline Brook project include deep sump catch basins, stream relocation work, diversion structures, stone rip rap outlets and rock cross vanes. Deep sump catch basins with sumps between 2′ and 4′ for this project, remove approximate 25% TSS as a pretreatment device, including trash and debris. Diversion structures were included as part the conveyance of stormwater runoff to the bioretention areas, which assist in conveying stormwater runoff to the sediment forebays. Stone rip rap in outlets reduces the velocity of stormwater runoff, essentially limiting scouring and erosion in the brook and also removing TSS prior to discharging in the brook. Rock cross vanes reduce streambank erosion, provide sediment transport, maintain channel capacity and dissipate

excess energy. A 290-foot section of Caroline Brook was relocated to stabilize and protect a sanitary sewer pipe which had been undercut and exposed by bank erosion.

The BMP's described above were installed in 2014-2015 as part of the Fuller Park Preservation Project. The overall watershed that runs through Caroline Brook from Seaward Road to State Street is approximately 16.15 acres. The total streambank restoration work from Caroline Brook to Forest Street is approximately 615 linear feet. The stream relocation is approximately 290 linear feet. The following table shows calculated pollutant loads and estimated removal due to the deep sump catch basins.

	TSS (#/yr)	TP (#/yr)	TN (#/yr)	Bacteria (#col/100 ml)
Deep Sump CB 1 (Bioretention Area 2)	438	0	0	0
Deep Sump CB 2 (Biorentention Area 2)	456	0	0	0

4. We have included non-structural BMP's in the project with include operation and maintenance of all BMP's, future maintenance of Caroline Brook, educational material provided on the Town's website, and interpretive signs in the field that describe stormwater BMP's. The interpretive signs, which have been installed in Caroline Brook, educate the public on stormwater management, including describing components of the BMP that help to improve water quality.

Summary Total Pollutant Load Removal

	TSS (#/yr)	TP (#/yr)	TN (#/yr)	Bacteria (#col/100 ml)
Bioretention 1	545.4	2	11	180
Deep Sump CB 3	202	0	0	0
Bioretention 2	2,415	8	47	787
Deep Sump CB 1	438	0	0	0
Deep Sump CB 2	456			

BMP Pollutant Load Calculations

The Simple Method - Pollutant Loading Calculations

Assumptions

	C values (mg/L)
	residential runoff *
TSS	100
Phosphorus - total	0.4
Nitrogen - total	3.31
Bacteria (#col/100ml)	7,000

* From The Watershed Treatment Model, 2001

Simple Method - Chemical constituents

L=0.226*R*C*A
L=Annual load (lbs)
R=Annual runoff (inches)
C=pollutant concentration (mg/l)
A=Drainage Area (acres)
0.226=Unit conversion factor

R=P*Pj*Rv
R=Annual runoff (inches)
P=Annual rainfall (inches)
Pj=Fraction of annual rainfall events that produced runoff, typically (0.9)
Rv=runoff coefficient=0.05+0.9la
la=Impervious fraction

Simple Method - Bacteria

L=1.03*(10^-3)*R*C'*A
L=Annual load (Billion Colonies/yr)
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A=Drainage Area (acres)
1.03=Unit conversion factor

R=P*Pj*Rv
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Suggested Removal Rates for BMP's (Massachusetts Stormwater Standards, 2008

	TSS	TP	TN	Bacteria (CWP, 2007)
Biorentention Systems	90%	60%	40%	70%
Deep Sump Catch Basins	25%	0	0	0

Bioretention 1 - Caroline Street

Total Area (acres)	3.8	Ia=	22%	
Impervious Area (acres)	0.84	Rv=	25%	
		P=	42	NOAA-Boston
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	TSS	TP	TN	Bacteria
C (residential)=	100	0.4	3.31	7000
Annual Load, L (lbs/yr)=	808	3.2	26.7	257.8

Deep Sump Catch Basin 3

	TSS	TP	TN	Bacteria
Load Removed (lbs/yr)*	202	0	0	0
Total Load Remaining (lbs/yr)	606	0	0	0
Difference	25%	0	0	0

Removal from Bioretention 1 (treating 100% of WQv)

	TSS	TP	TN	Bacteria
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Total Load Remaining (lbs/yr)	60.5	1.3	16	77.3
Difference	90%	60%	40%	70%

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Bioretention Area 2 - Seaward Road

Total Area (acres)	7.60	Ia=	24%	
Impervious Area (acres)	1.8	Rv=	27%	
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		R=	10.2	

Bioretention Area 2 – Abbott Road

Total Area (acres)	4.75	Ia=	44%	
Impervious Area (acres)	2.1	Rv=	45%	
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		R=	17	

Deep Sump Catch Basin 1

	TSS	TP	TN	Bacteria
C (residential)=	100	0.4	3.31	7,000
Annual Load, L (lbs/yr)=	1,752	14.1	116.7	1,124.9

Deep Sump Catch Basin 2

	TSS	TP	TN	Bacteria
C (residential)=	100	0.4	3.31	7,000
Annual Load, L (lbs/yr)=	1,825	14.1	116.7	1,124.9

Deep Sump Catch Basin 1

	TSS	TP	TN	Bacteria
Load Removed (lbs/yr)*	438	0	0	0
Total Load Remaining (lbs/yr)	1,314	0	0	0
Difference	25%	0	0	0

Deep Sump Catch Basin 2

	TSS	TP	TN	Bacteria
Load Removed (lbs/yr)*	456	0	0	0
Total Load Remaining (lbs/yr)	1,369	0	0	0
Difference	25%	0	0	0

Removal from Bioretention Area 2(treating 100% of WQv)

	TSS	TP	TN	Bacteria
Load Removed (lbs/yr)*	2,415	8	47	787
Total Load Remaining (lbs/yr)	268	5.6	70	337.5
Difference	90%	60%	40%	70%

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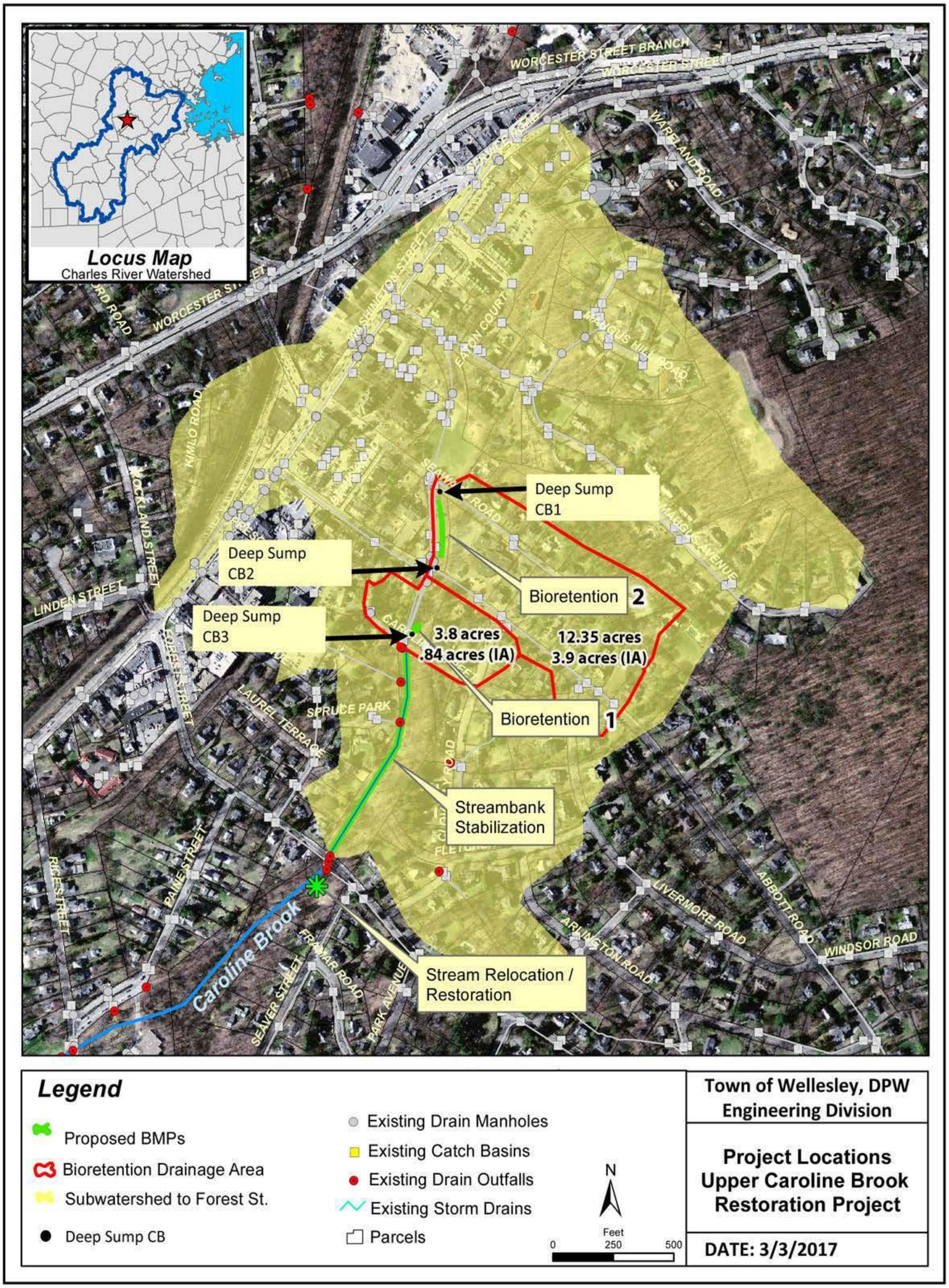
Streambank Stabilization – Estimated Pollutant Load Reductions

The effectiveness of stream restoration for pollutant removal has not been fully ascertained. However, EPA's Chesapeake Bay Program issued a guidance document in 2005 indicating how it would credit jurisdictions for reducing pollutant loads to the bay and its tidal rivers by means of stream restoration. In the guidance, the Chesapeake Bay Program included removal-efficiency rates based on research involving one stream restoration project along Spring Branch in Baltimore County, MD (USEPA 2005). The research included monitoring data from one year before and three years after construction of the Spring Branch project. For every linear foot of stream restored, the EPA guidance stipulates removals of 2.55 pounds per year of TSS, 0.02 pound per year of TN, and 0.0035 pound per year of TP. http://foresternetwork.com/daily/water/stormwater/comparing-lid-and-stream-restoration/

Stabilization Location	Length of stream stabilization (lf)	TSS Removed (lbs/year)	TP Removed (lbs/year)	TN Removed (lbs/year)
Streambank Stabilization between Forest Street and Caroline Street (Add Alternate 1 on plans)	615	1,568.3	2.2	12.3
Stream Relocation and Restoration Area	285	726.8	1.0	5.7
	Total:	**2,295**	**3.15**	**18**

The estimations used in this report were determined using the appropriate estimation models and applied according to the procedures prescribed for the model. To the best of my knowledge these are reasonable estimates using the appropriate methods. Documentation is kept on file by the grantee and is available for review by MassDEP/EPA.

David J. Hickey, Jr., P.E.
Town Engineer


Locus Map
Charles River Watershed
WORCESTER STREET BRANCH
WORCESTER STREET
WORCESTER ST
WABAN STREET
WASHINGTON STREET
EATON COURT
MAUGUS HILL ROAD
KIMLO ROAD
ROCKLAND STREET
LINDEN STREET
FOREST STREET
LAUREL TERRACE
SPRUCE PARK
MAUGUS AVENUE
Deep Sump
CB1
Deep Sump
CB2
Deep Sump
CB3
Bioretention 2
3.8 acres
.84 acres (IA)
12.35 acres
3.9 acres (IA)
Bioretention 1
Streambank
Stabilization
PAINE STREET
RICE STREET
Caroline Brook
FRAMAR ROAD
SEAVER STREET
PARK AVENUE
Stream Relocation /
Restoration
LIVERMORE ROAD
ARLINGTON ROAD
ABBOTT ROAD
WINDSOR ROAD
Legend
Proposed BMPs
Bioretention Drainage Area
Subwatershed to Forest St.
Deep Sump CB
Existing Drain Manholes
Existing Catch Basins
Existing Drain Outfalls
Existing Storm Drains
Parcels
N
Feet
0
250
500
Town of Wellesley, DPW
Engineering Division
Project Locations
Upper Caroline Brook
Restoration Project
DATE: 3/3/2017

TOWN OF WELLESLEY
WELLESLEY, MASSACHUSETTS 02481

20 MUNICIPAL WAY
781-235-7600
FAX 781-237-0047

DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION

March 9, 2017

RE: Certification of Completion of BMP's Upper Caroline Brook Restoration Project Town of Wellesley, Project No. 15-03/319

The following Best Management Practices for Stormwater (BMP's) were constructed under my direction as part of the Upper Caroline Brook Restoration Project. All BMPs were installed consistent with construction documents and environmental permits issued for the project.

1. Two bioretention basins and associated drainage connections to direct stormwater discharges from three municipal streets into infiltration and soil filtration infrastructure.
2. Stream and streambank improvements to 900 linear feet of stream bed and 1800 linear feet of streambank to reduce soil erosion, filter stormwater before it enters the brook, and · improve stream flow and habitat.
3. Deep sump catch basins on Forest Street to eliminate direct road stormwater discharges to Caroline Brook.
4. Relocation of 290 linear feet of stream to reduce the threat of sanitary sewer failure, provide additional floodplain, and provide for greater stormwater infiltration before entering the brook.
5. Provide public outreach and education through a project website and installation of two interpretive signs at the major stormwater BMP installation.

Sincerely,

David J. Hickey, Jr., P.E.
Town Engineer

Upper Caroline Brook Restoration Project
Project 15-03/319
List of Project Deliverables

Task 1: Quality Assurance and Project Evaluation

1. Modeled results of pollutant load reductions – See Section D – Description of BMP's
2. Documentation of BMP implementation – See Section D and attached project photos

Task 2: Design and Construct Stormwater Management BMP's

1. Final Design and Construction Plans – CD only
2. Construction and Wetland Permits
3. Final As-Built Drawings – Will not be available until completion of larger Fuller Brook Park Preservation Project.
4. Certification that BMP's installed per plan – See attached letter from Town Engineer
5. Digital format photodocumentation – CD only

Task 3: Operation and Maintenance Plan

1. Attached
2. Technical memo of O&M activities

Task 4: Public Education and Outreach

1. Summary of Outreach and Education activities – See Section B – Descriptive Summary

Task 5: Reporting and Project Oversight

1. Quarterly progress reports – Included in submitted invoices
2. Invoices – Four invoices submitted including all required attachments
3. Final Report – this document
4. Final report hard copies (2) and CD's(3)

Project Photographs

Bioretention Basin 1. Caroline Street

Bioretention Basin 1. Forebay

Bioretention Basin 2. Seaward and Abbott Streets

Stream Improvements. Upper Caroline Brook

Stream relocation area below Forest Street showing newly constructed stream channel.

Interpretive sign at Abbott Street discussing stormwater management through bioretention.

Interpretive sign at Forest Street discussing stream relocation to protect infrastructure and new stream channel and floodplain.

Fuller Brook Park Preservation Project
Park Maintenance and Management Plan

In support of the Town of Wellesley's Fuller Brook Park Preservation Project, the Massachusetts Department of Environmental Protection provided financial support for important water quality improvement elements including construction of two large bioretention basins, roadway drainage improvements, and stream restoration activities. An important grant requirement was to prepare a maintenance and management plan to guide the town in protecting this investment by assuring their designed functions continue to be viable into the future.

The following describes maintenance requirements for the park improvements funded through DEP Water Quality Improvement Grant Program, Project 15-03/319, Upper Caroline Brook Restoration Project.

All of Fuller Brook Park, the streets and municipal utility systems in it are owned, operated, and maintained by the Town of Wellesley through its Natural Resources Commission and Department of Public Works. Funding for operations and maintenance comes primarily from annual budget appropriations. Funding for capital projects is through the Town's capital improvement program and the community preservation committee.

A. Bioretention Systems

The maintenance objective for this type of stormwater management feature includes maintaining the hydraulic and pollutant removal capacity of the bioretention system and maintaining a healthy native, vegetative cover. The systems include three elements: drainage structures, sediment forebays, and bioretention areas.

1. <u>Drainage Structures (Underdrains, Overflow Structure, Diversion Structures, Catchbasins,and Drainage Pipes):</u> All drainage structures should be inspected annually and after major storm events to monitor for proper operation, collection of solids, litter and/or trash, and structural deterioration. The structures should be cleaned annually, or when the depth of sediment exceeds one half the depth from the bottom of the invert, and repaired when required. Accumulated sediment shall be removed and disposed of properly.

2. <u>Sediment Forebays:</u> The sediment forebays function as pretreatment for the bioretention areas. A general inspection of the forebays shall be conducted annually and after major storm events. Maintenance work consists of the following:
   - Removal of any trash and/or debris.
   - Removal of sediment when buildup is greater than or equal to 3 inches. Sediment should be removed by hand to minimize damage to plants. Any plants damaged or removed during sediment removal should be replaced with the same plant genus and species as shown on the Construction Plans. All sediment removed from these structures shall be disposed of in accordance with all applicable regulations.
   - Correction of any side slope erosion gullying, animal burrowing or slope slumping, and replanting as necessary.
   - Correction of any erosion along the bottom of the forebays. Repair with the existing stone or replace with similarly sized stone (see Construction Plans), as necessary.

- Correct any settling of the check dams between the sediment forebays and the bioretention areas. Correct any erosion that has occurred around the edges of check dams.
- Remove and replace vegetation as necessary, using the appropriate species as originally installed, as shown on the Construction Plans.

3. Bioretention Areas: A general inspection of the bioretention area shall be conducted annually and after major storm events. Maintenance work consists of the following:
   - Removal of any trash and/or debris.
   - Correction of any side slope erosion gullying, animal burrowing or slope slumping, and replanting as necessary.
   - If standing water is observed in the bioretention areas 48 hours after a storm event, the top 6 inches of the bioretention soil/mulch area shall be rototilled or cultivated to breakup any hard-packed sediment, and replenished with mulch and replanted. The underdrain system shall be snaked and/or flushed. Replant with species, as originally installed, as shown on the Construction Plans.
   - In a worst-case scenario, the entire filter bed may need to be re-installed. Upon failure, excavate bioretention soil, rake the pea gravel to loosen, inspect underdrain trench to determine if it has been compromised, repair as necessary, replace soil, replant, and mulch.
   - Plant maintenance is critical to the function of the bioretention area and should include removing and replacing as necessary with appropriate species, as originally supplied, or as shown on the Construction Plans.

Estimated Annual Maintenance Requirements: Drainage structures - 18 hours, Sediment Forebays - 16 hours, Bioretention areas - 32 hours

Estimated Future Capital Needs: For purposes of projecting capital needs it is anticipated that the bioretention areas may need to be reconstructed every 10 years.

A. Roadway Drainage Systems

Maintenance of drainage infrastructure is critical to the health of the park, flood prevention, and improving water quality in Caroline and Fuller Brooks. Catch basins and drainage culverts should be inspected annually and sediments in excess of six inches deep removed. Outfalls should be inspected after storms and areas of bank erosion repaired. Evidence of in stream sedimentation should be traced to a source. The DPW maintains the drainage systems proximate to the brook under and Order of Conditions issued by the Town Wetlands Committee.

Estimated Maintenance Requirements: Annual inspection and routine maintenance - 32 hours

Estimated Future Capital Needs: With adequate maintenance drainage infrastructure should have a design life in excess of 25 years.

B. **Streambanks**

Streambanks are delineated wetland resource areas which are defined by an observable break in topography up gradient of a water body or the mean annual flood level whichever is lower. They are significant resources to flood control, storm damage prevention, wildlife habitat, and water quality protection. Most of the stream banks at Fuller Brook Park evolved from grass slopes to vegetated banks due to lack of maintenance. Consequently, the majority of plants found along the banks are those which colonize such environments quickly, often invasive species. The management intent for the stream banks is to use a variety of measures to stabilize the toe of the bank and to establish native plantings with strong root systems to stabilize the soil and out compete exotic invasive species.

The capital improvement project will stabilize the toes of the banks, stabilize steep slopes, remove invasive vegetation, and establish a strong vegetative cover to the top of the banks. Maintenance of the stream banks will be a significant management activity required following construction, until the newly planted banks support a dense plant cover. Promoting the establishment of vegetation on the replanted banks and the identification and control of invasive species will require a significant on-going effort.

A more detailed description of the streambank and in-stream restoration features and recommended inspection and maintenance activities is provided in Appendix 3 which follows.

Estimated Maintenance Requirements: Annual inspection and slope repairs 56 hours
Estimated Future Capital Needs: Replacement plantings from proposed planting fund

C. Stream Course

The reconstruction of the stream course is intended to create a stable and self-sustaining ecosystem. This does not mean that no maintenance will be required. At least annual inspections should be made to identify areas of bank erosion, identify areas of siltation, monitor sediment build-up in the micropool features, and to keep the brook clear of tree limbs and other debris that might constrict flow.

A more detailed description of anticipated maintenance of the in stream features from the restoration project is provided in Appendix 3.

Estimated Maintenance Requirements: Annual inspections and debris removal 56 hours
Estimated Future Capital Needs: Stream course should be self-sustaining.

Appendix 3

Fuller Brook Park
Stream Restoration Features and Maintenance

Stream Restoration Features
The Fuller Brook Park Preservation Project includes stream restoration using both hard (stone revetment, riprap, and boulders) and soft (natural fiber and logs) bank stabilization, as well as in-stream practices to redirect high velocity flows away from eroding banks and create habitat. Attaining acceptable bank and channel stability requires an extended period for the restoration to become established. While site and hydrological conditions strongly influence the amount of time needed for establishment, a three-year timeframe should be considered. It is critical that the Town and the general public have a clear understanding that restoration goals are not achieved the day the contractor leaves.

The stream bed and banks will adjust in the first few years of the project as hydraulic forces move and grade materials, and project features may require modifications and/or design enhancements to address minor damage from bankfull flows. But as woody vegetation is established and its root mass increases, the system will become increasingly capable of handling these flows without altering the stream's geometry, and the overall operation and maintenance of the project will decrease. The ultimate goal of the stream restoration design is to establish a stream system which will be basically self-maintaining, remaining stable under most flow conditions. However, even after establishment, an act of nature can produce unforeseen events such as debris flows, which can alter the performance of in-channel structures and reduce their effectiveness.

Since the project is designed to be self-maintaining, routine and periodic maintenance of the various components is expected to be minimal. The inspection schedule and the anticipated maintenance activities are described below:

SCHEDULE
Both routine annual and periodic inspections should be conducted of the stream restoration features.

<u>Annual Inspections</u>
Detailed annual inspections should be performed for three (3) years after construction is complete. If the first three(3) annual inspections demonstrate stability in the stream reach, with no significant change in any of the projects features, detailed inspections may be reduced to a period of once every five (5) years. Annual visual inspections of the project should still occur, and in the event a problem is noted, a detailed inspection should be scheduled to evaluate the observed changes. Annual inspections will include, but are not limited to:

a. Conditions of structures, note voids, missing rock, dislodged logs, or irregular erosional patterns.
b. Condition of vegetation, evaluate establishment rate, mortality, inspect for signs of disease and insect damage, review and clearing actions or other disturbances to the vegetation.
c. Photo documentation of structures, vegetation and other stream features.

Periodic Inspections
Visual inspections of the stream restoration features should be conducted after significant runoff events (equal to or greater than the 1-year storm event). If a post-event inspection occurs within six months prior to an annual inspection, the annual inspection is not required.

Observations of the stream restoration features from park users and abutters are valuable tools for assessing the effectiveness of the design; they typically observe the project under the widest range of conditions, and their constant exposure to the work enables them to provide valuable information about its performance and condition. Park users and abutters should be encouraged to take pictures of the stream and contact the NRC to report their observations and/or concerns.

OPERATION AND MAINTENANCE ACTIVITIES

Streambank Stabilization Features
The streambank stabilization features for this project include the following:
- Soft Stabilization
    - Coir Fiber Log/Compost Sock Bank Stabilization
    - Coir Fabric
    - Log Reinforcement and Live Staking
- Hard Stabilization
    - Log/Boulder Bank Stabilization
    - Granite Toe Protection
    - Riprap Slopes and Outfall Protection
    - Imbricated Quarry Stone Revetment

In general, the streambank along the project reach should be inspected for evidence of increased erosion and/or new areas of erosion. These are indications that the design and construction of the stabilization and/or the in-stream features may need to be evaluated and adjusted to address their unintended effects.

Soft Stabilization
Soft stabilization practices are used in areas of lower stream velocities and shear stress. Maintenance in these areas should be low once vegetation is fully established (live stakes and conservation seed mix) along the streambanks. Anticipated maintenance includes:
- Replanting shall occur in areas where vegetation does not become established after construction, or where disease and other stresses (e.g., extreme flows, disturbance in order to repair in-stream structures, etc.) result in loss of vegetation.
- Eroded, slumped, or otherwise misplaced coir fabric, coir fiber logs/compost socks, logs, topsoil, and/or fill shall be reset or replaced with similar size, color, quantity and quality.
- As the logs used for toe reinforcement biodegrade, supplemental stabilization may be required in these areas if vegetation has not fully stabilized the bank.

Hard Stabilization
Hard stabilization is used in areas of higher velocity and shear stress. Inspections of these practices should mainly look for signs of rock movement and erosion. Anticipated maintenance includes:
- If any rocks become dislodged by either stream action or frost heaving, reset stone and/or replace with larger diameter stone as needed.
- Repair the stone revetment if it is leaning away from the design slope or if excessive fill material is being lost from behind the wall.

- Eroded, slumped, or otherwise misplaced stone, riprap, logs, and/or fill shall be reset or replaced with similar size, color, quantity and quality.

<u>In-Stream Features</u>
The in-stream restoration features for this project include the following:
- Boulder Clusters
- Log Vanes
- Rock Cross-Vanes

In general, the channel along the project reach should be inspected for evidence of large-scale deposition (aggradation) or incision (degradation). Visual inspection of the reaches located upstream and downstream of the project area should also be performed to look for any evidence of erosion, deposition, or lateral migration, as well as excessive turbidity. In projects utilizing these in-stream techniques, some changes are expected as the channel adjusts to the new pool depths and depositional patterns, until a new equilibrium is reached. However, continued impacts characterized by erosion of the streambanks or repetitive damage to the in-stream structures will require a detailed analysis of their design and construction.

In-stream structures may require some modification and enhancement as the stream adjusts to the new conditions. Anticipated maintenance activities associated with the in-stream features are as follows:

<u>Boulder Clusters</u>
Boulder clusters are groups of boulders (usually three) set on footer stones that are placed into the stream channel at specific locations. They create changes in flow patterns and provide habitat/resting locations in the small scour pools created on the downstream side of each boulder.

Anticipated maintenance includes:
- If high flows or debris cause the boulders to be dislodged, re-adjust the boulders in the original design location. If even frequent flows dislodge a boulder, it should be replaced by one with a larger diameter.
- If new areas of bank erosion are observed near a boulder cluster, the stream placement may need to be adjusted and/or replace with smaller diameter boulders.

<u>Log Vanes</u>
Log vanes are structures that made of large trees and boulders that are embedded into the bank and extend out into the channel, pointing upstream. These structures redirect erosive flow away from vulnerable banks, allowing vegetation to become established.

Anticipated maintenance includes:
- Maintenance of the log vanes is primarily associated with ensuring that the structures maintain their design standards with regard to how the log is keyed into the bank, the slope of the vane arms, location of the boulders, and the clearing of any debris which may be hung up after significant flood events.
- As the logs biodegrade, supplemental stabilization may be required in these areas if vegetation has not fully stabilized the bank.

<u>Rock Cross-Vanes</u>
Rock cross-vanes are boulder structures placed in a U-shape, pointing upstream. The vane arms are keyed into the bank at bankfull elevation to prevent scour around the structure. The vane sill

is the instream portion, which is comprised of a layer of embedded footer rocks, and top rocks that are slightly offset in the upstream direction. The top rocks are placed with gaps between them, but are flush with the footer rocks below. This feature is used to concentrate flows to the center of the channel (and away from eroding banks) and create a varied pool/riffle flow regime.

Anticipated maintenance includes:

- In the event that high flows or debris cause any rock(s) to be dislodged from the cross vane, or should the placement of the rock be altered such that the vane does not function properly, replace and/or adjust the placement of the rock.
- Address any observed rotational collapse of footer rocks and undesirable scour by reducing or filling voids between the top and footer rocks. The voids are the primary cause of the rotational collapse, allowing flow concentration between the rock layers, resulting in excess scour of the plunge pool immediately downstream of the structure and a collapse of the footer rocks into the scour pool. These voids also create a potential barrier to fish passage during low flows.
- Replace and reset the top rocks along the vane where deemed necessary to ensure more of a cascade than a drop.
- Backfill the vane arms with large cobble fill to reduce any voids.
- Replace the material at the bottom and/or at the exit (head of the riffle) of the scour pool with larger cobble material as needed to prevent excessive sediment transport.
- If significant woody debris accumulates on any section of the vane, remove the debris if possible. In the event the debris is large in size and inaccessible by equipment, the materials may be cut into small sections and left for removal during the next flood event.
- Address flanking of the vane at the streambank by adjusting the elevation of the vane arms and properly keying the rocks into the bank. Add rock as necessary.